

# NanoTHOR: Low-Cost Launch of CubeSats and Nanosats to Interplanetary Trajectories

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CubeSat and nanosatellite technologies are rapidly evolving to the level of capability and maturity where they can play a significant supporting role in NASA's exploration of Near Earth Objects, the Moon, Mars, and other interplanetary bodies. However, currently there is a lack of frequent, affordable opportunities for launch of these small satellites into interplanetary trajectories. The "Nanosatellite Tethered High-Orbit Release" (NanoTHOR) effort, funded by NASA's Innovative Advanced Concepts (NIAC) Program, is developing a method for using a simple, lightweight tether mechanism to scavenge the orbital energy and residual propellant of rocket stages to enable nanosatellites to be delivered into interplanetary trajectories using ride-share opportunities on geostationary satellite launches.

The NanoTHOR module will ride with its nanosatellite payloads into geostationary transfer orbit on an upper stage rocket. After the rocket has completed its primary mission, the module will deploy the payloads at the end of a several-kilometer long tether. The system will then set the tether into rotation using the rocket's residual propellant; the use of a rotating tether as a 'lever arm' multiplies the delta-V of the rocket, requiring just a few meters-per-second of thrusting by the rocket to accelerate the nanosatellite payloads by over half a kilometer per second. The tether will then release the payload, injecting it into an Earth escape trajectory. The tether can then either be retracted or de-orbited within half an orbit

to eliminate risks of collisions with resident space objects. The NanoTHOR module will provide a low-cost, low-mass means to enable nanosatellites to be launched as ride-share payloads on GEO satellite missions and then delivered to deep-space trajectories. It will therefore enable NASA to affordably launch flotillas of low-cost nanosatellites into heliocentric orbits to conduct searches for near Earth objects (NEOs), to study potential targets for manned exploration of asteroids, to provide 'nowcasting' of solar weather conditions, and to serve as communications relays for manned and unmanned missions to Mars and beyond. In this briefing, we will present initial results of system design and performance analysis of the NanoTHOR system.

